DEPARTMENT OF ENVIRONMENT
ENVIRONMENTAL PROTECTION SERVICE
PACIFIC REGION

PROGRESS REPORT ON THE DECEMBER 7, 1982 WATER QUALITY SAMPLING IN MYRA CREEK AFTER THE IMPLEMENTATION OF THE GROUNDWATER AND SURFACE COLLECTION AND TREATMENT SYSTEM AT WESTMIN RESOURCES LIMITED ON VANCOUVER ISLAND

Regional Program Report 83-18

By

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1 INTRODUCTION

In 1981 Westmin Resources Ltd. were requested to conduct a water quality monitoring program at their mining site to identify the sources of heavy metal contamination to Myra Creek. The monitoring program results were reported in two reports to the Buttle Lake Study Committee (B.C. Research, 1981 and B.C. Research, 1982). The results of these studies showed that there was very high microbiological leaching of zinc and copper occuring in the waste rock and which had severely contaminated not only the surface waters but also the groundwater. As a result of this information, Westmin Resources Ltd. installed a water collection system to intercept these contaminated waters, treat it by adding lime, and then discharge the treated water to Myra Creek.

The collection and treatment system began its trial run in September 1982 and at the same time B.C. Research was commissioned to conduct a water quality monitoring program to assess its effectiveness. These results have since been reported in their Phase III report (B.C. Research, 1983).

The Environmental Protection Service conducted a one day site visit and monitoring program of the treatment works and Myra Creek on December 7, 1982. This report gives the results of the sampling done on Myra Creek.

2 METHODS - SAMPLE COLLECTION SITES AND ANALYSIS

Four sample sites on Myra Creek were selected of which one, MC1 was sampled on both the left bank (north) and on the right bank (south) (figure 1). This site was under the Myra Collection Pipe Bridge upstream of the Myra Ponds but downstream of the Lynx Ponds. Site MC2 was located midstream opposite the collection system pump house located at the end of the collection systems. Sites M1 and M2 are the same as those used by B.C. Research in their study. In order to determine if there was any variance in pollutant concentrations during the day, a complete set of data was taken twice at each station, except M1, which was only sampled in the morning.

For all sites, replicated grab samples were collected using a modified version of a replicated grab sampler reported by Oguss and Erlebach (1976). The sampler held six 1 liter sample bottles. Six 1 liter samples were collected at each site and three of these were individually analyzed for conductivity, turbidity, hardness, total dissolved residue and total residue. Temperature was taken using a hand held thermometer and pH was measured immediately using a Brinkman Model E288 pH meter.

For the heavy metal samples, each of the remaining three 1 liter bottles were used to fill two 250 ml bottles, one for total metals and the other for dissolved metals. This made three replicated samples for analysis for each station. The samples for total heavy metals were preserved immediately with nitric acid to a pH of < 2. For the dissolved metal samples, approximately 100 mls was filtered on site through a 0.45 micron cellulose nitrate filter. It was then preserved with nitric acid to a pH of < 2.

All samples were packed in wet ice and taken to the Environmental Protection Service/Department of Fisheries Laboratory in West Vancouver the next morning.

For the heavy metal analysis the samples were subjected to an ICAP (Inductively Coupled Argon Plasma) scan which is an automated Atomic

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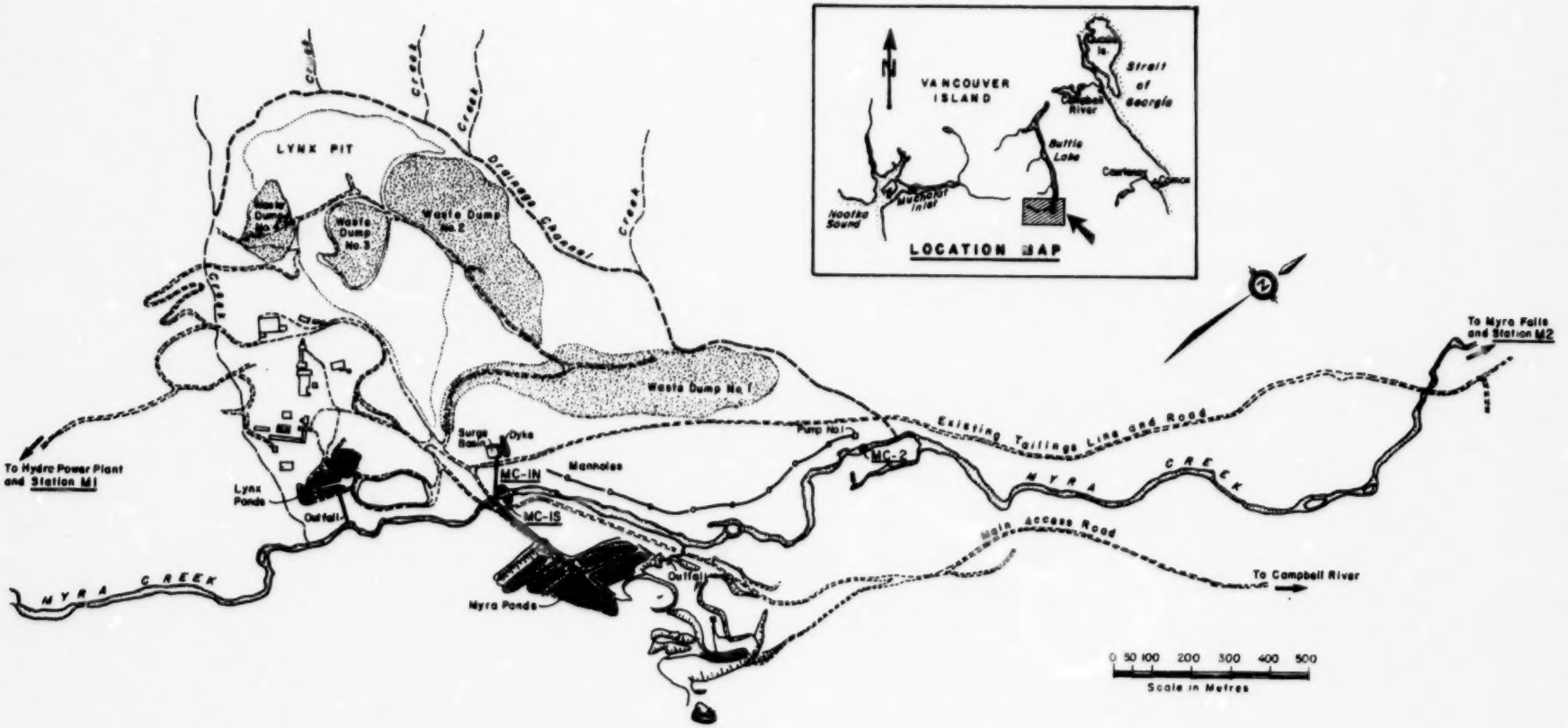

FIGURE 1 MINE SITE AND MYRA CREEK SAMPLE SITES

Emission Spectrophotometer that gives a reading for 26 metals. For Cu, Pb, and Cd, if the reading was below the ICAP detection limit, the samples were run again through the graphite furnace of the Atomic Absorption Spectrophotometer which has a lower detection limit.

3 RESULTS AND DISCUSSION

3.1 Physical Parameters

There was little or no difference in pH values at MC1 between the north and south banks, but the mean values were slightly higher in the second set rising from 6.70/6.73 to 7.15/7.20 (Table 1). The morning values were slightly lower than the control, M1, value of 7.02. For the first set at the pump house, MC2, and at M2 the values had risen slightly over MC1 to 6.83 and 6.80 respectively. These two stations dropped to 6.68 and 6.75 in the second set but the difference was within the standard deviation of the mean.

The temperature remained constant at 2°C with the exception of M2 which was 3°C at 9:15 in the morning (Table 1).

Turbidity at M1 and MC1 (north and south banks) was < 0.1 FTU for the first set of data and only MC1 on the north bank had a detectible reading of 0.1 FTU for the second set of data (Table 2). MC2 was < 0.1 FTU at 13:10 and just detectable at 0.1 FTU at 15:30. The furthest downstream station (M2) had a turbidity reading of 0.3 FTU's for both morning and afternoon samples. This was considerably lower than the April, 1982 samples at the Myra Falls (M2) which were 4.2 FTU's (Kelso and Jones, 1982).

Conductivity showed very little difference between morning and afternoon sampling (Table 2). The values on the north bank at MC1 were about 10 umhos/cm higher than the south bank. But, these values were approximately twice as high as the control (M1) which was 36.4 umhos/cm. Of further significance was that at MC2 the conductivity had more than doubled compared to MC1 which indicated there was still a significant contribution of ions entering the creek along the area where the collection system is located. There was only a slight increase between MC2 and M2.

TABLE 1 TEMPERATURE AND pH FOR MYRA CREEK AT FOUR STATIONS ON DECEMBER 7, 1982

	STATIONS				
	M1	MC1 (north bank)	MC1 (south bank)	MC2	M2
		pH			
Time	10:30	11:15	11:35	13:10	09:15
Replica					
1	6.90	6.75	6.65	6.90	6.8
2	7.00	6.65	7.00	6.78	-
3	7.15	-	6.55	6.80	-
$\bar{x}$	7.02	6.70	6.73	6.83	6.80
S.D.	0.13	0.07	0.24	0.06	-
		Temperature °C			
	2°	2°	2°	2°	3°
		pH			
Time	-	14:45	15:10	15:30	14:00
Replica					
1	N.M.	7.05	7.13	6.65	6.85
2	N.M.	7.35	7.18	6.70	6.65
3	N.M.	7.05	7.30	6.70	6.75
$\bar{x}$		7.15	7.20	6.68	6.75
S.D.		0.17	0.09	0.03	0.10
		Temperature °C			
	N.M.	2°	2°	2°	2°

N.M. - not measured.

TABLE 2 TURBIDITY AND CONDUCTIVITY FOR MYRA CREEK AT FOUR STATIONS AND AT VARIOUS TIMES ON DECEMBER 7, 1982

	STATIONS				
	M1	MC1 (north bank)	MC1 (south bank)	MC2	M2
			Turbidity (FTU)		
Time	10:30	11:15	11:35	13:10	09:15
Replica					
1	L0.1	L0.1	L0.1	L0.1	0.2
2	L0.1	L0.1	L0.1	L0.1	0.3
3	L0.1	L0.1	L0.1	L0.1	0.3
$\bar{x}$	L0.1	L0.1	L0.1	L0.1	0.3
S.D.	-	-	-	-	0.06
Time	-	14:45	15:10	15:30	14:00
Replica					
1	N.M.	0.1	L0.1	0.1	0.3
2	N.M.	0.1	L0.1	0.1	0.3
3	N.M.	0.1	L0.1	0.1	0.3
$\bar{x}$		0.1	L0.1	0.1	0.3
S.D.		-	-	-	-
			Conductivity (umhos/cm)		
Time	10:30	11:15	11:35	13:10	09:15
Replica					
1	36.7	80.2	65.9	156	157
2	36.2	79.1	65.9	155	157
3	36.2	78.5	65.9	155	156
$\bar{x}$	36.4	79.3	65.9	155	157
S.D.	0.3	0.9	-	0.6	0.6
Time	-	14:45	15:10	15:30	14:00
Replica					
1	N.M.	75.8	65.9	156	158
2	N.M.	74.7	65.9	155	158
3	N.M.	73.6	65.9	155	158
$\bar{x}$		74.7	65.9	155	158
S.D.		1.1	-	0.6	-

N.M. - not measured.

In April 1982 the values at M2 were 179 umhos/cm compared to the two December mean values of 157 and 158 umhos/cm (Kelso and Jones). B.C. Research in their Phase III study showed a range of between 50 and 150 umhos/cm from May 27, 1982 to March 2, 1983 (B.C. Research, 1983). Their values for samples collected at M2 nearest to our sample date of December 7, 1982 were 137 umhos/cm on November 26, 1982 and 140 umhos/cm on December 22, 1982. The B.C. Research values for M1 on these two dates were 34 and 32 umhos/cm respectively.

The residues were mostly in the dissolved form and increased from a mean total dissolved residue of 11 mg/l at M1 to 32 mg/l and 38 mg/l on the north bank in the morning and afternoon respectively, and 27 and 36 mg/l respectively on the south bank (Table 3). The value further increased at MC2 to 89 mg/l for the first data set and 86 mg/l for the second data set. There was a further slight increase to 90 mg/l and 94 mg/l at M2 (Myra Falls).

In April 1982 the total dissolved residues at M2 were 94 mg/l (Kelso and Jones, 1982) while B.C. Research (1983) reported values of 84 mg/l on November 26, 1982, and 116 mg/l on December 22, 1982. At M1 they reported values of 18 and 27 mg/l total solids for these two dates.

TABLE 3 RESIDUES FOR MYRA CREEK AT FOUR STATIONS AND AT VARIOUS TIMES ON DECEMBER 7, 1982

	STATIONS				
	M1	MC1 (north bank)	MC1 (south bank)	MC2	M2
Total Dissolved Residue (mg/l)					
Time	10:30	11:15	11:35	13:10	09:15
Replica					
1	13	36	24	87	90
2	9	32	25	91	90
3	10	29	34	88	90
$\bar{x}$	11	32	27	89	90
S.D.	2	4	6	2	-
Time	-	14:45	15:10	15:30	14:00
Replica					
1	N.M.	41	34	90	92
2	N.M.	31	36	85	92
3	N.M.	41	38	84	97
$\bar{x}$		38	36	86	94
S.D.		6	2	3	3
Total Residue (mg/l)					
Time	10:30	11:15	11:35	13:10	09:15
Replica					
1	13	36	24	87	90
2	9	32	25	91	90
3	10	36	34	88	90
$\bar{x}$	11	35	27	89	90
S.D.	2	2	6	2	-
Time	-	14:45	15:10	15:30	14:00
Replica					
1	N.M.	41	34	90	92
2	N.M.	37	36	94	92
3	N.M.	41	38	92	97
$\bar{x}$		40	36	92	94
S.D.		2	2	2	3

N.M. - not measured.

3.2 Chemical Parameters

3.2.1 Sulphates. The mean sulphate value at M1 (the control) was 1.8 mg/l (Table 4). The other sample stations indicated there was very little difference between the morning and afternoon sampling. However, there was a large difference between sample stations. At MC1, on the south bank, the mean values had increased from 7.9/8.2 to 12.9/11.2 on the north bank. Then at MC2 the values increased to 40 mg/l showing a significant input to the creek at or before this station. There was very little increase from MC2 to the falls at M2.

3.2.2 Metals and Hardness. The metals that are of the greatest concern are zinc, copper and cadmium. Also of interest in this study was aluminum, because of the aluminum hydroxide precipitation occuring in Myra Creek and the iron concentrations. All the other metals that are given by the ICAP scan are reported in the Appendix for readers that are interested in the results.

3.2.2.1 Copper. The dissolved copper values indicate that there appears to be some contamination in the samples taken from 10:30 am to 13:10 in the afternoon. The reason for this is not known, except that for those samples a different Sartoarious filtering apparatus was used than those taken at 09:15 or for the sets taken from 14:00 to 15:30 in the afternoon. The total copper results showed good replicated sampling with a consistantly low standard deviation (Table 5).

Mean total copper values had increased significantly at the north bank of Station MC1 compared to station M1 (< 0.001 to 0.025 mg/l). On the south bank the increase was small, with a mean of 0.004 mg/l. In the afternoon the MC1 (north bank) concentration was also higher with a mean of 0.016 mg/l. At this time the mean dissolved values were 0.015 mg/l which shows that copper is all in the dissolved fraction. Samples

TABLE 4 SULPHATE MEASUREMENTS FOR MYRA CREEK AT FOUR STATIONS AND AT VARIOUS TIMES ON DECEMBER 7, 1982

	STATIONS				
	M1	MC1 (north bank)	MC1 (south bank)	MC2	M2
Time	10:30	11:15	11:35	13:10	09:15
Replica					
1	1.8	12.9	8.1	40.1	41.5
2	2.0	13.0	7.8	40.8	41.3
3	1.5	12.8	7.9	40.8	42.0
$\bar{x}$	1.8	12.9	7.9	40.6	41.6
S.D.	0.3	0.1	0.2	0.4	0.4
Time	-	14:45	15:10	15:30	14:00
Replica					
1	N.M.	11.3	8.0	40.3	42.2
2	N.M.	11.2	8.5	40.5	41.9
3	N.M.	11.1	8.0	40.5	42.2
$\bar{x}$		11.2	8.2	40.4	42.1
S.D.		0.1	0.3	0.1	0.2

N.M. - not measured.

TABLE 5 REPLICATED COPPER CONCENTRATIONS (mg/l) AT FOUR STATIONS AND AT VARIOUS TIMES IN MYRA CREEK ON DECEMBER 7, 1982

	STATION									
	M1		MC1 (north bank)		MC1 (south bank)		MC2		M2	
	Total	Dissolved**	Total	Dissolved**	Total	Dissolved**	Total	Dissolved**	Total	Dissolved**
Time	10:30		11:15		11:35		13:10		09:15	
Replica										
1	L0.001*	0.015	0.025	0.051	0.004*	0.016	0.012	0.010*	0.024	0.014
2	L0.001*	0.006*	0.026	0.041	0.004*	0.005*	0.013	0.032	0.025	0.017
3	L0.001*	0.006*	0.023	0.020	0.004*	0.004*	0.013	0.027	0.026	0.015
$\bar{x}$	L0.001	0.009	0.025	0.037	0.004	0.008	0.013	0.023	0.025	0.015
S.D.	-	0.005	0.002	0.016	-	0.007	0.001	0.012	0.001	0.002
Time	-		14:45		15:10		15:30		14:00	
Replica										
1		N.M.	0.015	0.016	0.004*	0.004*	0.012	0.007*	0.024	0.018
2		N.M.	0.015	0.015	0.003*	0.004*	0.014	0.007*	0.023	0.018
3		N.M.	0.017	0.015	0.004*	0.003*	0.013	0.010*	0.023	0.024
$\bar{x}$			0.016	0.015	0.004	0.004	0.013	0.008	0.023	0.020
S.D.			0.001	0.001	0.001	0.001	0.001	0.002	0.001	0.003

ICAP Method unless otherwise indicated where * = AA

N.M. - not measured

** where dissolved levels higher than total, suspect contamination of dissolved samples.

collected at MC2, opposite the end of the collection system by the pumphouse, showed the mean total values declined to 0.013 mg/l in both the sample times. This would indicate that there was a source of contamination above the Myra pipeline overpass and this was being further mixed and diluted by the time it reached Station MC2. By M2 (Myra Falls) the values had again risen to 0.025 mg/l which indicated there is a source of contamination downstream of the collection system.

The values at M2 were reduced substantially from those found in April, 1982 (Kelso and Jones, 1982) which had a mean value of 0.217 mg/l dissolved copper. B.C. Research in their Phase III study showed a value of 0.04 mg/l total copper on December 9, 1982. Values, in the past, have been recorded by B.C. Research as high as 0.24 mg/l total copper and 0.16 mg/l dissolved copper at Station M2 (B.C. Research,1982).

3.2.2.2 Zinc. As with the dissolved copper samples there was contamination with the dissolved zinc samples except in the afternoon at Station MC1, north and south banks and at MC2 (Table 6).

Total zinc was less than the detection limit of 0.002 mg/l at M1 but increased 0.281 mg/l at MC1 (north bank) in the morning sample and was 0.187 mg/l in the afternoon. The south bank was considerably less with a mean of 0.039 mg/l. At MC2 the mean value was 0.162 mg/l in both sample sets. However, like the copper these values increased to 0.290 mg/l total zinc at M2. This again shows the contamination of the creek downstream of the collection system. At MC1 and MC2 the dissolved zinc values in the afternoon are almost the same as the total values which shows the zinc is all in the dissolved form.

In April, 1982 the total zinc level at M2 was 1.90 mg/l (Kelso and Jones, 1982). B.C. Research (1983) reported a total zinc value of 0.33 mg/l on December 9, 1982. The highest value reported in the Phase II study for total zinc was on March 16, 1982 of 2.06 mg/l (B.C. Research, 1982).

TABLE 6 REPLICATED ZINC CONCENTRATIONS (mg/l) AT FOUR STATIONS AND AT VARIOUS TIMES IN MYRA CREEK ON DECEMBER 7, 1982 (ICAP Method)

	STATION									
	M1		MC1 (north bank)		MC1 (south bank)		MC2		M2	
	Total	Dissolved**	Total	Dissolved**	Total	Dissolved**	Total	Dissolved**	Total	Dissolved**
Time	10:30		11:15		11:35		13:10		09:15	
Replica										
1	L0.002	0.020	0.291	0.321	0.039	0.054	0.162	0.421	0.291	0.805
2	L0.002	0.015	0.282	0.308	0.039	0.095	0.161	0.165	0.287	0.272
3	L0.002	0.303	0.270	0.501	0.038	0.124	0.164	0.169	0.291	0.543
$\bar{x}$	L0.002	0.113	0.281	0.377	0.039	0.091	0.162	0.252	0.290	0.540
S.D.	-	0.165	0.011	0.108	0.001	0.035	0.002	0.147	0.002	0.267
Time	-		14:45		15:10		15:30		14:00	
Replica										
1		N.M.	0.187	0.182	0.040	0.037	0.164	0.154	0.290	0.282
2		N.M.	0.190	0.182	0.039	0.036	0.161	0.156	0.291	0.480
3		N.M.	0.185	0.181	0.041	0.035	0.161	0.153	0.288	0.290
$\bar{x}$			0.187	0.182	0.040	0.036	0.162	0.154	0.290	0.351
S.D.			0.003	0.001	0.001	0.001	0.002	0.002	0.002	0.112

N.M. - not measured

** where dissolved values greater than total, suspect contamination of dissolved samples.

3.2.2.3 Cadmium. Cadmium was only at or slightly above the detection limit at MC1 on the north bank and at M2 where the mean total cadmium concentration was 0.0007 mg/l in the morning and 0.0006 mg/l in the afternoon (Table 7). This corresponds to a value of 0.0007 mg/l that B.C. Research found on December 7, 1982 at M2 (B.C. Research 1983). The highest value B.C. Research reported in the Phase II study was 0.006 mg/l total Cd on February 5, 1982 (B.C. Research, 1982).

3.2.2.4 Aluminum. The B.C. Research phase II study (1982) showed that Myra Creek had approximately ten times more zinc in the vicinity of the "milky springs" area than from any other source. They conducted an analysis of the white precipitate and found that the main constituent was a hydroxide of aluminum.

At M1 the mean total aluminum concentration was just detectable at 0.06 mg/l while the dissolved concentration was < 0.05 mg/l. At MC1 on the north bank the values ranged from 0.17 mg/l total aluminum in the morning to a mean of 0.10 mg/l in the afternoon (Table 8). On the south bank the total levels were below the detection limit of < 0.06 mg/l. At M2 the mean total level was 0.13 mg/l and 0.14 mg/l for both data sets. This was mostly in the dissolved form. However, at station M2 the total aluminum concentration had doubled to 0.26 mg/l compared to MC2 while the dissolved fraction increased only slightly. In comparison to the April 1982 total value of 1.56 mg/l, this is a decrease of 84% in the concentration (Kelso and Jones, 1982).

3.2.2.5 Iron. There was very little variation between the morning and afternoon sampling (Table 9). At M1, the mean total concentration was 0.013 mg/l and the mean dissolved concentration was at the detection limit of 0.005 mg/l. The mean total iron concentration increased to over 0.030 mg/l at MC1 and almost doubled again at MC2. There was no evidence of additional loadings downstream at M2 and the mean dissolved iron

TABLE 7 REPLICATED CADMIUM CONCENTRATIONS (mg/l) AT FOUR STATIONS AND AT VARIOUS TIMES IN MYRA CREEK ON DECEMBER 7, 1982 (AA Method)

	STATION									
	M1		MC1 (north bank)		MC1 (south bank)		MC2		M2	
	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved
Time	10:30		11:15		11:35		13:10		09:15	
Replica										
1	L0.0006	L0.0005	0.0006	0.0007	L0.0006	L0.0005	L0.0006	L0.0005	0.0006	0.0007
2	L0.0006	L0.0005	0.0006	0.0007	L0.0006	L0.0005	L0.0006	L0.0005	0.0007	0.0007
3	L0.0006	L0.0005	0.0006	0.0007	L0.0006	L0.0005	L0.0006	L0.0005	0.0007	0.0006
$\bar{x}$	L0.0006	L0.0005	0.0006	0.0007	L0.0006	L0.0005	L0.0006	L0.0005	0.0007	0.0007
S.D.	-	-	-	-	-	-	-	-	0.0001	0.0001
Time	-		14:45		15:10		15:30		14:00	
Replica										
1	N.M.		L0.0006	L0.0005	L0.0006	L0.0005	L0.0006	L0.0005	L0.0006	0.0007
2	N.M.		L0.0006	L0.0005	L0.0006	L0.0005	L0.0006	L0.0005	0.0006	0.0007
3	N.M.		L0.0006	L0.0005	L0.0006	L0.0005	L0.0006	L0.0005	0.0006	0.0008
$\bar{x}$			L0.0006	L0.0005	L0.0006	L0.0005	L0.0006	L0.0005	0.0006	0.0007
S.D.			-	-	-	-	-	-	0.0001	0.0001

N.M. - not measured

TABLE 8 REPLICATED ALUMINUM CONCENTRATIONS (mg/l) AT FOUR STATIONS AND AT VARIOUS TIMES IN MYRA CREEK ON DECEMBER 7, 1982 (ICAP Method)

	STATION									
	M1		MC1 (north bank)		MC1 (south bank)		MC2		M2	
	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved
Time	10:30		11:15		11:35		13:10		09:15	
Replica										
1	0.06	L0.05	0.17	0.12	0.06	0.05	0.15	0.10	0.27	0.16
2	L0.06	L0.05	0.17	0.14	L0.06	0.05	0.11	0.11	0.25	0.15
3	0.07	L0.05	0.16	0.13	L0.06	0.06	0.12	0.11	0.27	0.13
$\bar{x}$	0.06*	L0.05	0.17	0.13	L0.06*	0.05	0.13	0.11	0.26	0.15
S.D.	0.01	-	0.01	0.01	-	0.01	0.02	0.01	0.01	0.02
Time	-		14:45		15:10		15:30		14:00	
Replica										
1	N.M.		0.11	0.09	L0.06	L0.05	0.12	0.11	0.25	0.15
2	N.M.		0.08	0.08	L0.06	L0.05	0.14	0.09	0.26	0.15
3	N.M.		0.11	0.10	L0.06	L0.05	0.15	0.11	0.25	0.17
$\bar{x}$			0.10	0.09	L0.06	L0.05	0.14	0.10	0.25	0.16
S.D.			0.02	0.01	-	-	0.02	0.01	0.01	0.01

* detection limit used in calculating mean
N.M. - not measured

TABLE 9 REPLICATED IRON CONCENTRATIONS (mg/l) AT FOUR STATIONS AND AT VARIOUS TIMES IN MYRA CREEK ON DECEMBER 7, 1982 (ICAP Method)

	STATION									
	M1		MC1 (north bank)		MC1 (south bank)		MC2		M2	
	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved
Time	10:30		11:15		11:35		13:10		09:15	
Replica										
1	0.016	0.006	0.038	0.027	0.031	0.022	0.063	0.043	0.061	0.033
2	0.013	0.005	0.037	0.029	0.039	0.022	0.051	0.045	0.059	0.030
3	0.011	L0.005	0.037	0.026	0.030	0.021	0.062	0.042	0.061	0.029
$\bar{x}$	0.013	0.005	0.037	0.027	0.033	0.022	0.059	0.043	0.060	0.031
S.D.	0.003	0.001	0.001	0.002	0.005	0.001	0.007	0.002	0.001	0.002
Time	-		14:45		15:10		15:30		14:00	
Replica										
1	N.M.		0.032	0.024	0.030	0.021	0.058	0.042	0.053	0.031
2	N.M.		0.032	0.024	0.033	0.021	0.058	0.042	0.053	0.031
3	N.M.		0.038	0.024	0.030	0.021	0.058	0.043	0.051	0.034
$\bar{x}$			0.034	0.024	0.031	0.021	0.058	0.042	0.052	0.032
S.D.			0.003	-	0.002	-	-	0.001	0.001	0.002

N.M. - not measured

concentration decreased from 0.043 mg/l to 0.031 mg/l in the morning and from 0.042 mg/l to 0.032 mg/l in the afternoon. In April 1982 the mean total value at M2 was 0.205 mg/l which shows the concentrations have decreased by 73% (Kelso and Jones, 1982).

3.2.2.6 Hardness. Hardness is a measurement of the calcium and magnesium ions. There was very little difference between the morning and afternoon sampling (Table 10). As with the main metals there was a higher concentration on the north bank than on the south bank a Station MC1. These values doubled by station MC2 to over 60.0 mg/l. However, there was very little difference between MC2 and M2. There was also very little difference between the April, 1982 (Kelso and Jones, 1982) mean total hardness value of 70.3 mg/l and the values obtained in December of 66.5 and 67.3 mg/l by B.C. Research (1983).

TABLE 10 REPLICATED HARDNESS VALUES (mg/l) AT FOUR STATIONS AND AT VARIOUS TIMES IN MYRA CREEK ON DECEMBER 7, 1983 (ICAP Method)

	STATION									
	M1		MC1 (north bank)		MC1 (south bank)		MC2		M2	
	Ca, Mg	Total	Ca, Mg	Total	Ca, Mg	Total	Ca, Mg	Total	Ca, Mg	Total
Time	10:30		11:15		11:35		13:10		09:15	
Replica										
1	16.0	16.3	31.3	32.7	26.6	27.0	61.7	63.0	65.4	67.8
2	15.8	16.1	31.2	32.6	24.5	25.0	61.5	62.5	62.9	64.3
3	15.9	16.7	30.9	32.6	24.5	25.1	62.3	63.3	65.1	67.4
$\bar{x}$	15.9	16.4	31.1	32.6	25.2	25.7	61.8	62.9	64.7	66.5
S.D.	0.1	0.3	0.2	0.1	1.2	1.1	0.4	0.4	1.5	1.9
Time	-		14:45		15:10		15:30		14:00	
Replica										
1	N.M.		29.4	30.3	26.1	26.5	63.9	65.0	65.9	67.4
2	N.M.		29.2	30.1	26.2	26.6	64.3	65.2	65.0	66.8
3	N.M.		29.2	30.1	25.7	26.1	63.4	64.5	66.0	67.6
$\bar{x}$			29.3	30.2	26.0	26.4	63.9	64.9	65.6	67.3
S.D.			0.1	0.1	0.3	0.3	0.5	0.4	0.6	0.4

N.M. - not measured

4 SUMMARY AND CONCLUSIONS

The data collected on December 7, 1982 shows that there is still a significant loading of copper and zinc to Myra Creek. Sample site MC1 which is the beginning of the collection site had a loading of total zinc and total copper of 67.0 and 5.87 kg/day respectively. Most of this loading is coming from the mine site above the collection system.

Between MC1 and MC2 (which is the end of the collection system) the loadings of zinc and copper further increased to 81.3 kg/day and 6.53 kg/day respectively (Table 11). The loadings from the Myra Pond treatment system are only 3.4 kg/day total zinc and 0.35 kg/day total copper which shows that there is still a further source of contamination to the creek which is not being picked up by the collection system.

Below the collection system, between MC2 and M2 (at the Myra Falls) the loadings further increased to 159.9 kg/day zinc and 13.23 kg/day copper.

However, when one compares these loading to loadings prior to the installation of the collection system it is obvious that the treatment system is working. On April 16, 1982 the loadings at M2 were 502.3 kg/day of zinc and 57.4 kg/day of copper (Table 11). Therefore in December, 1982 there is a decrease of 68% in zinc loadings and 77% in copper loadings over the April 16, 1982 loadings.

Westmin Resources Limited in their Stage II Submission, Addendum 1 (1982) states that the zinc loadings in the creek after implementation of the collection and treatment system mainly originates between the groundwater pumphouse (MC2) and the falls (M2). When comparing the December 7/82 and April 16/82 data EPS has collected, although Westmin have more sample points or dates, this is not entirely correct. In looking at Table 11 one can calculate that the increase from MC2 to M2 is about 50% of the total loadings.

In the Stage II Addendum they contribute this downstream loading to the pyritic waste rock contained within the tailing line road and they

TABLE 11 LOADING OF TOTAL ZINC AND TOTAL COPPER AT EACH OF THE SAMPLE SITES WITHIN AND DOWNSTREAM OF THE WESTMIN MINE SITE

STATION	MYRA POND EFFLUENT	MC1	MC2	M2	
				Dec. 7, 1982	April 16, 1982
Flow (m^3/sec)	0.152[1]	5.66[3]	5.81[5]	6.38[6]	3.06[6]
Concentration (mg/l)					
Zn	0.259[2]	0.137[4]	0.162	0.290	1.90
Cu	0.027[2]	0.012[4]	0.013	0.024	0.217
Loadings (kg/day)					
Zn	3.4	67.0	81.3	159.9	502.3
Cu	.35	5.87	6.53	13.23	57.4

[1]Based on influent flow taken from the Stage II, Addendum 1 Westmin Resources Ltd. 1982.
[2]Unpublished data - Keith Ferguson, Environmental Protection Service, Dec. 7, 1982.
[3]MC2 flow less the Myra Pond effluent estimate which was based on the influent flow .
[4]Mean of both morning and afternoon sampling of north and south banks.
[5]Calculated by using .91 times M2 flow (personal communication B. Hallam, Westmin).
[6]Based on gauge reading 46.5 cm for December 7/82 and 32.0 cm for April 16/82 and using the stage discharges curve from the Hydrology Report of B.C. Research Phase II Monitoring Report.

list a number of possible control measures to deal with this contamination. However, there will have to be further sampling conducted to determine the exact amount and source of the other 50% loadings to the creek.

5 REFERENCES

1. B.C. Research: Water Quality in the Thelwood and Myra Creek Drainages, Phase I. Report to the Buttle Lake Study Committee, 1981.

2. B.C. Research: Phase II Monitoring (Hydrology, Water Quality, Groundwater) at the Buttle Lake Site, Westmin Resources Ltd. Operations. Volume I and II. Report to the Buttle Lake Study Committee, 1982.

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4. Kelso, B.W., and M. Jones: Replicated Water Quality Sampling in Myra Creek, April 16, 1982. Environment Canada, EPS Regional Program Report: 82-09, 1982.

5. Ogus, E., and W.E. Erlebach: Limitations of Single Water Samples in Representing Mean Water Quality. Environment Canada Inland Waters Directorate Tech. Bull. No. 95, 1976.

6. Westmin Resources Limited: Water Collection and Treatment Evaluation, Surface and Groundwater Collection, Myra Integrated Water Treatment System, Myra Creek Response. Stage II Submission, Addendum 1, 1982.

APPENDIX I

METAL CONCENTRATIONS IN MYRA CREEK, DECEMBER 7, 1982

MYRA CREEK - DECEMBER 7, 1982
HEAVY METALS THAT WERE BELOW THE DETECTION LIMIT (units in mg/l)

METAL	DETECTION LIMIT
Arsenic	0.06
Baryllium	0.001
Cobalt	0.006
Chromium	0.006
Mercury	0.06
Molybdenum	0.006
Nickel	0.02
Phosphorus	0.06
Lead	0.001
Antimony	0.06
Selenium	0.06
Tin	0.01
Titanium	0.002
Vanadium	0.01
Silica	0.01

BARIUM (mg/l)

	STATION									
	M1		MC1 (north bank)		MC1 (south bank)		MC2		M2	
	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved
Time	10:30		11:15		11:35		13:10		09:15	
Replica										
1	0.005	0.005	0.006	0.007	0.005	0.007	0.011	0.011	0.013	0.015
2	0.005	0.006	0.006	0.006	0.006	0.006	0.011	0.011	0.013	0.013
3	0.005	0.006	0.006	0.007	0.005	0.006	0.011	0.011	0.013	0.013
$\bar{x}$	0.005	0.006	0.006	0.007	0.005	0.006	0.011	0.011	0.013	0.014
S.D.	-	0.001	-	0.001	0.001	0.001	-	-	-	0.001
Time	-		14:45		15:10		15:30		14:00	
Replica										
1	N.M.		0.006	0.006	0.006	0.005	0.011	0.010	0.013	0.013
2	N.M.		0.006	0.006	0.006	0.005	0.011	0.010	0.013	0.013
3	N.M.		0.006	0.005	0.006	0.005	0.011	0.010	0.013	0.013
$\bar{x}$			0.006	0.006	0.006	0.005	0.011	0.010	0.013	0.013
S.D.			-	0.001	-	-	-	-	-	-

N.M. - not measured

BORON (mg/l)

	STATION									
	M1		MC1 (north bank)		MC1 (south bank)		MC2		M2	
	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved
Time	10:30		11:15		11:35		13:10		09:15	
Replica										
1	L0.001	L0.001	L0.001	0.009	L0.001	L0.001	L0.001	L0.001	L0.001	L0.001
2	L0.001	L0.001	L0.001	L0.001	0.012	0.004	0.002	L0.001	0.009	L0.001
3	0.009	L0.001	L0.001	L0.001	0.009	L0.001	0.009	L0.001	L0.001	L0.001
$\bar{x}$	0.004*	L0.001	L0.001	0.004*	0.007*	0.002*	0.004*	L0.001	0.004*	L0.001
S.D.	0.005	-	-	0.005	0.006	0.002	0.004	-	0.005	-
Time	-		14:45		15:10		15:30		14:00	
Replica										
1		N.M.	0.019	0.016	L0.001	0.009	0.009	0.008	0.009	L0.001
2		N.M.	0.019	L0.001	0.009	L0.001	L0.001	L0.001	L0.001	L0.001
3		N.M.	0.009	0.009	L0.001	L0.001	L0.001	0.008	L0.001	L0.001
$\bar{x}$			0.016	0.009*	0.004*	0.004*	0.004*	0.004*	0.004*	L0.001
S.D.			0.006	0.008	0.005	0.005	0.005	0.005	0.005	-

N.M. - not measured

*detection limit used to calculate mean

CALCIUM (mg/l)

	STATION									
	M1		MC1 (north bank)		MC1 (south bank)		MC2		M2	
	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved
Time	10:30		11:15		11:35		13:10		09:15	
Replica										
1	6.0	6.0	11.3	11.4	10.1	10.0	24.1	23.1	24.9	24.0
2	6.0	5.9	11.2	11.4	10.1	9.2	23.8	23.0	24.6	23.1
3	6.0	6.0	11.1	11.3	10.0	9.2	24.5	23.3	24.8	24.1
$\bar{x}$	6.0	6.0	11.2	11.4	10.1	9.5	24.1	23.1	24.8	23.7
S.D.	-	0.1	0.1	0.1	0.1	0.5	0.4	0.2	0.2	0.6
Time	-		14:45		15:10		15:30		14:00	
Replica										
1		N.M.	11.2	10.9	10.4	9.9	24.6	24.0	25.0	24.2
2		N.M.	11.4	10.8	10.3	9.9	24.0	24.1	25.0	23.11
3		N.M.	11.1	10.8	10.4	9.7	24.0	23.8	24.7	24.3
$\bar{x}$			11.2	10.8	10.4	9.8	24.2	24.0	24.9	24.1
S.D.			0.2	0.1	0.1	0.1	0.3	0.2	0.2	0.2

N.M. - not measured

MAGNESIUM (mg/l)

	STATION									
	M1		MC1 (north bank)		MC1 (south bank)		MC2		M2	
	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved
Time	10:30		11:15		11:35		13:10		09:15	
Replica										
1	0.3	0.2	0.7	0.7	0.4	0.4	1.0	1.0	1.3	1.3
2	0.2	0.3	0.7	0.7	0.3	0.4	1.0	1.0	1.3	1.3
3	0.3	0.3	0.7	0.7	0.3	0.4	1.0	1.0	1.3	1.3
$\bar{x}$	0.3	0.3	0.7	0.7	0.3	0.4	1.0	1.0	1.3	1.3
S.D.	0.1	0.1	-	-	0.1	-	-	-	-	-
Time	-		14:45		15:10		15:30		14:00	
Replica										
1		N.M.	0.5	0.5	0.4	0.4	1.0	1.0	1.3	1.3
2		N.M.	0.5	0.5	0.4	0.4	1.0	1.0	1.3	1.3
3		N.M.	0.5	0.6	0.4	0.4	1.0	1.0	1.3	1.3
$\bar{x}$			0.5	0.5	0.4	0.4	1.0	1.0	1.3	1.3
S.D.			-	0.1	-	-	-	-	-	-

N.M. - not measured

MANGANESE (mg/l)

	STATION									
	M1		MC1 (north bank)		MC1 (south bank)		MC2		M2	
	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved
Time	10:30		11:15		11:35		13:10		09:15	
Replica										
1	L0.001	L0.001	0.073	0.075	0.007	0.007	0.030	0.028	0.052	0.050
2	L0.001	L0.001	0.071	0.073	0.007	0.007	0.030	0.029	0.052	0.048
3	L0.001	L0.001	0.068	0.070	0.007	0.006	0.031	0.029	0.052	0.050
$\bar{x}$	L0.001	L0.001	0.071	0.073	0.007	0.007	0.030	0.029	0.052	0.049
S.D.	-	-	0.003	0.003	-	0.001	0.001	0.001	-	0.001
Time	-		14:45		15:10		15:30		14:00	
Replica										
1		N.M.	0.046	0.045	0.007	0.007	0.031	0.029	0.052	0.050
2		N.M.	0.047	0.045	0.007	0.007	0.030	0.029	0.053	0.050
3		N.M.	0.046	0.045	0.007	0.007	0.030	0.029	0.052	0.050
$\bar{x}$			0.046	0.045	0.007	0.007	0.030	0.029	0.052	0.050
S.D.			0.001	-	-	-	0.001	-	0.001	-

N.M. - not measured

SODIUM (mg/l)

	STATION									
	M1		MC1 (north bank)		MC1 (south bank)		MC2		M2	
	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved
Time	10:30		11:15		11:35		13:10		09:15	
Replica										
1	0.7	0.6	1.4	1.3	1.2	1.2	1.4	1.4	1.4	1.4
2	0.7	0.6	1.3	1.3	1.2	1.1	1.4	1.4	1.4	1.3
3	0.7	0.6	1.3	1.3	1.2	1.1	1.4	1.4	1.4	1.4
$\bar{x}$	0.7	0.6	1.3	1.3	1.2	1.1	1.4	1.4	1.4	1.4
S.D.	-	-	0.1	-	-	0.1	-	-	-	0.1
Time	-		14:45		15:10		15:30		14:00	
Replica										
1		N.M.	1.3	1.2	1.2	1.2	1.4	1.4	1.4	1.4
2		N.M.	1.3	1.2	1.2	1.2	1.4	1.4	1.4	1.4
3		N.M.	1.2	1.2	1.2	1.1	1.5	1.4	1.4	1.4
$\bar{x}$			1.3	1.2	1.2	1.2	1.4	1.4	1.4	1.4
S.D.			0.1	-	-	0.1	0.1	-	-	-

N.M. - not measured

STRONTIUM (mg/l)

	STATION									
	M1		MC1 (north bank)		MC1 (south bank)		MC2		M2	
	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved
Time	10:30		11:15		11:35		13:10		09:15	
Replica										
1	0.010	0.011	0.030	0.031	0.026	0.027	0.047	0.046	0.047	0.046
2	0.010	0.011	0.030	0.031	0.026	0.024	0.046	0.045	0.046	0.044
3	0.010	0.011	0.029	0.030	0.026	0.024	0.048	0.046	0.047	0.046
$\bar{x}$	0.010	0.011	0.030	0.031	0.026	0.025	0.047	0.046	0.047	0.045
S.D.	-	-	0.001	0.001	-	0.002	0.001	0.001	0.001	0.001
Time	-		14:45		15:10		15:30		14:00	
Replica										
1		N.M.	0.030	0.029	0.028	0.026	0.049	0.047	0.047	0.046
2		N.M.	0.031	0.029	0.028	0.027	0.047	0.048	0.047	0.045
3		N.M.	0.030	0.029	0.028	0.026	0.047	0.046	0.047	0.046
$\bar{x}$			0.030	0.029	0.028	0.026	0.048	0.047	0.047	0.046
S.D.			0.001	-	-	0.001	0.001	0.001	-	0.001

N.M. - not measured

POOR

QUALITY

ORIGINAL